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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA-15815 (MARCH 2003)
NASA
SUPERSEDING NASA-15815 (MARCH 2002)

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DIVISION 15 - MECHANICAL

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NASA-15815 (MARCH 2003)
NATIONAL AERONAUTICS **NASA**
AND SPACE ADMINISTRATION **SUPERSEDING NASA-15815 (MARCH 2002)**

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SECTION 15815

LOW PRESSURE DUCTWORK
03/03

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NOTE: Delete, revise, or add to the text in this section to cover project requirements. Notes are for designer information and will not appear in the final project specification.

This section covers low pressure ductwork for air conditioning systems.

Drawings should supplement specifications by showing limits of duct materials and duct pressure classification; support provisions; type branch take-offs; elbows used for attenuation; location of extractors, dampers, linings, air diffusion devices; curbing at duct floor penetrations; framing or flanged duct segments at wall penetrations; vibration isolation of ducting.

Rigid fibrous-glass ductwork shall not be used.

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PART 1 GENERAL

1.1 REFERENCES

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NOTE: The following references should not be manually edited except to add new references. References not used in the text will automatically be deleted from this section of the project specification.

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The publications listed below form a part of this section to the extent referenced:

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325	(1991) Manual of Steel Construction Load and Resistance Factor Design

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M	(2002) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 36/A 36M	(2001) Standard Specification for Carbon Structural Steel
ASTM A 653/A 653M	(2002) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM F 1137	(2000) Standard Specification for Phosphate/Oil and Phosphate/Organic Corrosion Protective Coatings for Fasteners

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2002) Standard for the Installation of Air Conditioning and Ventilating Systems

SHEET METAL & AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA HVAC DCS	1995; 2nd Ed) HVAC Duct Construction Standards - Metal and Flexible

UNDERWRITERS LABORATORIES (UL)

UL 181	(1996; 9th Ed) UL Standards for Safety Factory-Made Air Ducts and Air Connectors
UL 555	(1999; 6th Ed) UL Standard for Safety Fire Dampers

1.2 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01330, "Submittal Procedures," and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control. Include a columnar list of appropriate products and tests beneath each submittal description.

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The following shall be submitted in accordance with Section 01330, "Submittal Procedures," in sufficient detail to show full compliance with the specification:

SD-01 Preconstruction Submittals

Material, Equipment, and Fixture Lists shall be submitted for low pressure ductwork systems in accordance with paragraph entitled, "General Requirements," of this section.

SD-02 Shop Drawings

The following shall be submitted for low pressure ductwork systems in accordance with paragraph entitled, "Design Requirements," of this section.

Connection Diagrams
Fabrication Drawings
Installation Drawings
As-Built Drawings

SD-03 Product Data

Design Analysis and Calculations shall be submitted for low pressure ductwork systems in accordance with paragraph entitled, "Design Requirements," of this section.

Manufacturer's catalog data shall be submitted for the following items:

Galvanized Steel Ductwork Materials
Flexible Duct Materials
Power Operated Dampers
Flexible Connectors
Fire Dampers and Wall Collars
Gravity Backdraft and Relief Dampers
Manual Volume Dampers

SD-04 Samples

Manufacturer's Standard Color Chart shall be submitted in accordance with paragraph entitled, "General Requirements," of this section.

SD-06 Test Reports

Test reports shall be submitted for low pressure ductwork systems on the following tests in accordance with the paragraph entitled, "Ductwork Leakage Tests" and "Fire Damper Tests," of this section.

Operation Tests
Ductwork Leakage Tests

SD-07 Certificates

Records of Existing Conditions shall be submitted in accordance with paragraph entitled, "General Requirements," of this section.

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals shall be provided for:

Power Operated Dampers
Fire Dampers and Wall Collars

1.3 PERFORMANCE REQUIREMENTS

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NOTE: If Section 15003, "General Mechanical Provisions," is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted. If Section 15072, "Vibration Isolation for Air Conditioning Equipment," is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted.

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[Section 15003, "General Mechanical Provisions," applies to work specified in this section.]

[Section 15072, "Vibration Isolation for Air Conditioning Equipment," applies to work in this section.]

1.4 DESIGN REQUIREMENTS

Low-pressure systems shall encompass ductwork and plenums where maximum air velocity is 2,000 feet per minute(fpm) 10.1 meter per second and maximum static pressure is 2 inches 500 pascal water gage (wg), positive or negative.

Rigid fibrous-glass ductwork shall not be used.

Fabrication Drawings shall be submitted for low pressure ductwork systems consisting of fabrication and assembly details to be performed in the factory. Drawings shall show details of equipment room layout and design.

Connection Diagrams shall be submitted for low pressure ductwork systems indicating the relation and connection of devices and apparatus by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

Design Analysis and Calculations shall be submitted for low pressure ductwork systems indicating the manufacturer's recommended air velocities, maximum static pressures, temperature calculations and acoustic levels.

Installation Drawings shall be submitted for low pressure ductwork systems in accordance with the manufacturer's recommended instructions.

As-Built Drawings shall provide current factual information including

deviations from, and amendments to the drawings and concealed or visible changes in the work, for low pressure ductwork systems.

Manufacturer's Standard Color Chart shall indicate the manufacturer's standard color selections and finishes for low pressure ductwork.

1.5 GENERAL REQUIREMENTS

Records of Existing Conditions shall be submitted consisting of the results of Contractor's survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work shall constitute acceptance of existing conditions.

Material, Equipment, and Fixture Lists shall include the manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

PART 2 PRODUCTS

2.1 GALVANIZED STEEL DUCTWORK MATERIALS

Galvanized steel ductwork sheet metal shall be carbon steel, of lock-forming quality, hot-dip galvanized, with regular spangle-type zinc coating, conforming to ASTM A 653/A 653M, G235 Z600. Duct surfaces to be painted shall be treated by phosphatizing.

Sheet metal gages and reinforcement thickness shall conform to SMACNA HVAC DCS, except for minimum standards stated herein.

MINIMUM SHEET METAL GAGE

DUCT WIDTH INCHES	GAGE
0 - 12	26
13 - 30	24
31 - 60	22

MINIMUM SHEET METAL THICKNESS

DUCT WIDTH MILLIMETER	THICKNESS
0 - 305	0.45
330 - 762	0.61
787 - 1524	0.76

2.1.1 Duct Hangers

Duct hangers in contact with galvanized duct surfaces shall be [galvanized] [black carbon] steel painted with inorganic zinc.

2.1.2 Mill-Rolled Reinforcing and Supporting Materials

Mill-rolled structural steel shall conform to ASTM A 36/A 36M and, whenever in contact with sheet metal ducting, shall be galvanized in accordance with ASTM A 123/A 123M.

Equivalent strength, proprietary-design, rolled-steel structural support systems may be submitted for approval in lieu of mill-rolled structural steel.

2.2 FLEXIBLE DUCT MATERIALS

Flexible duct connectors shall be in accordance with UL 181, Class 1 material and shall comply with NFPA 90A.

[Metal duct shall be bendable through 180 degrees without damage, with an inside bend radius not greater than one-half the diameter of duct. Metal shall be [aluminum] [carbon steel] zinc-coated ASTM A 123/A 123M.]

[Wire-reinforced cloth duct shall consist of a [chloroprene] [vinyl-impregnated and coated] fibrous-glass cloth bonded to and supported by a corrosion-protected spring steel helix. Fabric may be a laminate of metallic film and fibrous glass. Working pressure rating of ducting shall be not less than three times maximum system pressure, and temperature range shall be minus 20 to plus 175 degrees F 29 to plus 79 degrees C.]

[Wire-reinforced fibrous-glass duct shall consist of a minimum[1] [_____] 1 pound/cubic foot [4] [_____] 16 Kg/cubic meter density fibrous glass bonded to and supported by corrosion-protected spring helix. Vapor barrier shall be a [4] [_____] mil [0.102] [_____] millimeter minimum, pigmented polyvinylchloride film. Duct shall be bendable without damage through 180 degrees with an inside bend radius not greater than two duct diameters. Minimum wall thickness shall be [1] [_____] inch [25] [_____] millimeter. Thermal conductivity shall be not greater than [0.23] Btu per hour per square foot per degrees F] [0.40 watt per meter per degrees C] [_____] at 75 degrees F 24 degrees C mean. Permeance shall be not greater than [0.10 perm] [5.7] nanogram per pascal second square meter [_____]. Working pressure range shall be from minus [1/2] [_____]-inch [124] [_____] pascal wg to plus [1-1/2] [_____] inches [373] [_____] pascal wg. Working temperature shall range from minus 20 to plus 250 degrees F 29 to plus 121 degrees C. Minimum sustained velocity without delamination shall be [2,400] [_____] fpm [12.19] [_____] meter per second. Materials shall conform to NFPA 90A.

2.3 MANUAL VOLUME DAMPERS

Volume damper construction shall conform to SMACNA HVAC DCS.

Dampers shall be equipped with an indicating quadrant regulator with a locking feature externally located and easily accessible for adjustment. Where damper rod lengths exceed [30] inches [760] millimeter [_____], a regulator shall be provided at each end of damper shaft.

All damper shafts shall have two-end bearings.

Splitter damper shall be [[22]-gage [0.85] millimeter [_____] sheet metal] [[2] gages 0.25 millimeter [_____] heavier than duct in which installed]. Hinges shall be [full length piano-type] [1/8-inch 3 millimeter thick door type].

Damper shaft shall be full length and shall extend beyond damper blade. A [3/8]-inch [10] millimeter [_____] square shaft shall be used for damper lengths up to [20] inches [500] millimeter [_____] and a [1/2]-inch [15] millimeter square shaft shall be used for damper lengths [20] inches [500] millimeter [_____] and larger. Where necessary to prevent damper vibration or slippage, adjustable support rods with locking provisions external to duct shall be provided at damper blade end.

Dampers in ducts having a width perpendicular to the axis of the damper that is greater than [12] inches [300] millimeter [_____] shall be multiblade type having a substantial frame with blades fabricated of [16]-gage [1.6] millimeter [_____] metal. Blades shall not exceed [10] inches [250] millimeter [_____] in width and [48] inches [1220] millimeter [_____] in length and shall be [pinned] [welded] to [1/2]-inch [15] millimeter [_____] diameter shafts. Dampers greater than [48] inches [1220] millimeter [_____] in width shall be made in two or more sections with intermediate mullions, each section being mechanically interlocked with the adjoining section or sections. Blades shall have [graphite-impregnated nylon] [oil-impregnated sintered bronze] bearings and shall be connected so that adjoining blades rotate in opposite directions.

2.4 GRAVITY BACKDRAFT AND RELIEF DAMPERS

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NOTE: The following paragraphs do not cover light-duty equipment.
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Frame shall be constructed of not less than [1-1/2- by 4-inch 40 by 100 millimeter] [_____] reinforced [16]-gage [1.6] millimeter [_____] galvanized carbon steel. Frames and mullions shall be solidly secured in place and sealed with elastomer calking against air bypass.

Maximum blade width shall be [9] inches [230] millimeter [_____], and maximum blade length shall be [36] inches [900] millimeter [_____]. Blade material shall be [16-gage 1.6 millimeter galvanized steel] [14-gage1.99 millimeter [6063] [5052] alloy aluminum] [18-gage 1.3 millimeter AISI 18-8 corrosion-resistant steel]. Blades shall be provided with mechanically retained seals and 90-degree limit stops.

Dampers used for relief service shall have blades linked together to open not less than 30 degrees on 0.05-inch 12 pascal wg differential pressure.

Shaft bearings shall be [graphite-impregnated nylon] [oil-impregnated bronze].

Counterbalanced dampers shall be equipped with fixed or adjustable counterbalancing weights.

Gravity backdraft dampers in sizes [18 by 18 460 by 460] [_____] inches millimeter or smaller, when furnished integral with air moving equipment, may be equipment manufacturer's standard construction.

2.5 POWER-OPERATED DAMPERS

Dampers shall conform to applicable requirements specified under Section 15902, "Control Systems."

2.6 FLEXIBLE CONNECTORS FOR SHEET METAL

Connectors shall be UL-listed, 20-ounce .68 kilogram per square meter, fire-retardant, airtight, woven fibrous-glass cloth impregnated with chloroprene. Clear width, not including clamping section, shall be [3 to 5 76 to 125] [_____] inches millimeter.

2.7 FIRE DAMPERS AND WALL COLLARS

Fire damper locations shall be in accordance with NFPA 90A.

Fire dampers in ductwork shall be provided at firewall barriers.

Fire dampers shall be constructed and labeled in accordance with UL 555 to provide damper and mounting fire-resistance that equals or exceeds fire-resistance of the construction in which installed. For link loads in excess of [20] pounds [90] newton [_____], UL-approved quartzoid links shall be provided.

Wall collars shall be constructed in accordance with UL 555.

PART 3 EXECUTION

3.1 INSTALLATION

Sheet metal construction shall be provided in accordance with the SMACNA HVAC DCS and NFPA 90A.

Supplementary steel shall be designed and fabricated in accordance with AISC 325.

Fabrication shall be airtight and shall include necessary reinforcements, bracing, supports, framing, gasketing, sealing, and fastening to provide rigid construction and freedom from vibration, airflow-induced motion, noise, and excessive deflection at specified maximum system air pressure.

Dampers located behind architectural intake or exhaust louvers shall be enclosed by a rigid sheet metal collar and sealed to building construction with elastomers for complete air tightness.

Outside air-intake ducts and plenums shall be sheet metal and shall have soldered watertight joints.

Offsets and transformations shall be provided as required to avoid

interference with the building construction, piping, or equipment.

Wherever ducts pass through firewalls or through walls or floors dividing conditioned spaces from unconditioned spaces, a flanged segment shall be provided in that surface during surface construction.

Sheet metal surfaces to be painted or surfaces to which adhesives will be applied shall be clean and free of oil, grease, and deleterious substances.

Where interiors of ducting may be viewed through air diffusion devices, the viewed interior shall be sheet metal and shall be painted flat black.

Duct strength shall be adequate to prevent failure under pressure or vacuum created by fast closure of ductwork devices. Leaktight automatic relief devices shall be provided.

Plenum anchorage provisions, sheet metal joints, and other areas shall be made airtight and watertight by calking mating galvanized steel and concrete surfaces with a two-component elastomer.

3.2 RECTANGULAR SHEET METAL DUCTS

Angle iron frames shall be welded at corners and ends, whenever possible. Angle iron reinforcements shall be riveted or welded to ducts not more than [6] inches [150] millimeter [_____] on center, with not less than [two] [_____] points of attachment. Spot welding, where used, shall be 3 inches 75 millimeter on center.

Standard seam joints shall be sealed with an elastomer compound to comply with SMACNA HVAC DCS Seal Class A, B or C as applicable.

Crossbreaking shall be limited to [4] feet [1220] millimeter [_____] and shall be provided on all ducts [8] inches [200] millimeter [_____] wide and wider. Bead reinforcement shall be provided in lieu of crossbreaking where panel popping may occur. Where rigid insulation will be applied, crossbreaking is not required.

3.2.1 Longitudinal Duct Seams

Corner seams shall be Pittsburg lock [_____].

3.2.2 Joints and Gaskets

Companion angle flanges shall be bolted together with [1/4]-inch [8] millimeter [_____] diameter bolts and nuts spaced [6] inches [150] millimeter [_____] on center. Flanged joints shall be gasketed with chloroprene full-face gaskets [1/8] inch [3] millimeter [_____] thick, with Shore A 40 durometer hardness. Gaskets shall be one piece and [vulcanized] [dovetailed] at joints.

3.2.3 Flexible Duct Joints

Joints between flexible duct without sheet metal collars and round metal ductwork connections shall be made by trimming the ends, coating the inside

of the flexible duct for a distance equal to depth of insertion with elastomer calk, and by securing with sheet metal screws or binding with a strap clamp.

3.2.4 Square Elbows

[Single-vane duct turns shall be provided in accordance with SMACNA HVAC DCS, and may be used on ducts 12 inches 300 millimeter wide and narrower.]

[Double-vane duct turns shall be provided in accordance with SMACNA HVAC DCS.]

3.2.5 Radius Elbows

Radius elbows shall conform to SMACNA HVAC DCS. Radius elbows shall have an inside radius equal to the width of the duct. Where installation conditions preclude use of standard elbows, the inside radius may be reduced to a minimum of [0.25] [_____] times duct width and turning vanes shall be installed in accordance with the following schedule.

WIDTH OF ELBOWS	RADIUS OF TURNING VANES IN PERCENT OF DUCT WIDTH		
INCHES	VANE NO. 1	VANE NO. 2	VANE NO. 3
Up to 16	56	--	--
17 to 48	43	73	--
49 and over	37	55	83

WIDTH OF ELBOWS	RADIUS OF TURNING VANES IN PERCENT OF DUCT WIDTH		
MILLIMETER	VANE NO. 1	VANE NO. 2	VANE NO. 3
Up to 406	56	--	--
430 to 120	43	73	--
1245 and over	37	55	83

Where two elbows are placed together in the same plane in ducts 30 inches 760 millimeter wide and larger, the guide vanes shall be continuous through both elbows rather than spaced in accordance with above schedule.

3.2.6 Outlets, Inlets, and Duct Branches

Branches, inlets, and outlets shall be installed so that air turbulence will be reduced to a minimum and air volume properly apportioned. Adjustable splitter dampers shall be installed at all supply junctions to permit adjustment of the amount of air entering the branch. Wherever an air-diffusion device is shown as being installed on the side, top, or bottom of a duct, and whenever a branch takeoff is not of the splitter type, a commercially manufactured air extractor shall be provided to allow adjustment of the air quantity and to provide an even flow of air across the device or duct it services.

Where a duct branch is to handle more than [25] [_____] percent of the air handled by the duct main, a complete 90-degree increasing elbow shall be used with an inside radius of [0.75] [_____] times branch duct width. Size of the leading end of the increasing elbow within the main duct shall have the same ratio to the main duct size as the ratio of the related air quantities handled.

Where a duct branch is to handle [25] [_____] percent or less of the air handled by the duct main, the branch connection shall have a 45 degree side take-off entry in accordance with SMACNA HVAC DCS Fig 2-6.

3.2.7 Duct Transitions

Where the shape of a duct changes, the angle of the side of the transition piece shall not exceed [15] [_____] degrees from the straight run of duct connected thereto.

Where equipment is installed in ductwork, the angle of the side of the transition piece from the straight run of duct connected thereto shall not exceed [15] [_____] degrees on the upstream side of the equipment and [22-1/2] [_____] degrees on the downstream side of the equipment.

3.2.8 Branch Connections

Radius tap-ins shall be constructed in accordance with SMACNA HVAC DCS.

3.2.9 Access Openings

Access doors and panels shall be installed in ductwork [upstream from coils] [upstream and downstream from coils] [adjacent to fire dampers] [at controls or at any item requiring periodic inspection, adjustment, maintenance, or cleaning] [where indicated], and every 20 feet 6.1M for indoor air quality housekeeping purposes.

Minimum size of access opening shall be [12 by 18 305 by 460] [_____] inches millimeter, unless precluded by duct dimensions or otherwise indicated.

Access door construction shall be in accordance with SMACNA HVAC DCS, except that sliding doors may be used only for special conditions upon prior approval. Insulated doors shall be double-panel type.

Access doors that leak shall be made airtight by adding or replacing hinges and latches or by construction of new doors adequately reinforced, hinged, and latched.

****

NOTE: Select the following paragraph when there is need for frequent duct cleaning.

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[Duct access shall be particularly suitable for commercial duct cleaning methods utilizing vacuum devices. Access openings shall be spaced with a

frequency and at points which will permit ready access to duct internals with essentially no duct or insulation cutting. Where access through an air-diffusion device or through access doors specified herein is not available at a specific point, [8]-inch [200] millimeter [_____] diameter, [16]-gage [1.6] millimeter [_____] access plates shall be provided not more than [10] feet [3000] millimeter [_____] on center. Where duct is insulated and vapor-sealed, mastic seals shall be provided around circumference of access. When access plate is in place and insulated, the location shall be externally identified.]

3.2.10 Duct Supports

Selection of hanging system shall be at the Contractor's option. The following support sizes, configurations, and spacings are given to show the minimal type of supporting component required. Where installed loads are excessive for the specified hanger spacings, hangers, and accessories, [heavier-duty components shall be provided] [the hanger spacing may be reduced]. After system startup, any duct support device which, due to length, configuration, or size, vibrates or causes possible failure of a member or damage to ducting shall be replaced or the condition shall be alleviated.

Hanger rods, angles, and straps shall be attached to beam clamps. Concrete inserts and masonry anchors and fasteners shall be approved for the application.

[Hardened high-carbon spring-steel fasteners fitted onto beams and miscellaneous structural steel are acceptable upon prior approval of each proposed application and upon field demonstration of conformance to specification requirements. Fasteners shall be made from steel conforming to AISI Type [C1055] [C1070], and shall be treated and finished in accordance with ASTM F 1137, zinc phosphate base. A [72] [_____]-hour load-carrying capacity shall be verified by a certified independent laboratory. Hanger spacing shall be limited to provide 20-to-1 safety factor for supported load. Maximum weight supported by any two fasteners shall be 100 pounds 445 newton. Friction rod assemblies are not acceptable.]

[Where support from metal deck systems is required, support requirements shall be coordinated with installation of metal deck.]

Ductwork and equipment shall not be hung from roof deck, piping, or other ducts or equipment. Maximum span between any two points shall be [10] feet [3000] millimeter [_____] with lesser spans for duct assemblies, interferences, and loads imposed or permitted.

There shall be not less than [one] [_____] set of hangers for each point of support. Hangers shall be installed on both sides of all duct turns, branch fittings, and transitions.

Hangers shall be sufficiently cross-braced to eliminate vertical and lateral sway.

Rectangular ducts up to [36] inches [915] millimeter [_____] shall be

supported by strap hangers attached at not less than [three] [_____] places to not less than [two] [_____] duct surfaces in different planes.

Perforated strap hangers shall not be acceptable.

Rectangular ducting, [36] inches [915] millimeter [_____] and larger, shall be supported by trapeze hangers. Ducts situated in unconditioned areas and required to have insulation with a vapor-sealed facing shall be supported on trapeze hangers. Hangers shall be spaced far enough out from the side of the duct to permit the duct insulation to be placed on the duct inside of the trapeze. Under no circumstances shall duct hangers penetrate the vapor-sealed facing.

Where trapeze hangers are used, the bottom of the duct shall be supported on angles sized as follows:

WIDTH OF DUCT, INCHES	MINIMUM BOTTOM ANGLE SIZE, INCHES
30 and smaller	1-1/4 by 1-1/4 by 1/8
31 to 48	1-1/2 by 1-1/2 by 1/8
49 to 72	1-1/2 by 1-1/2 by 3/16
73 to 96	2 by 2 by 1/4
97 and larger	3 by 3 by 1/4

WIDTH OF DUCT, MILLIMETER	MINIMUM BOTTOM ANGLE SIZE, MILLIMETER
760 and smaller	32 by 32 by 3
790 to 1220	40 by 40 by 3
1245 to 1830	40 by 40 by 4.7
1855 to 2440	50 by 50 by 6
2465 and larger	80 by 80 by 6

Where ductwork system contains heavy equipment, excluding air-diffusion devices and single-leaf dampers, such equipment shall be hung independently of the ductwork by means of rods or angles of sizes adequate to support the load.

Ducting supported from roof purlins shall be supported at points not greater than one-sixth of the purlin span from the roof truss. Load per hanger shall not exceed [400] pounds [1780] newton [_____] when support is from a single purlin or [800] pounds [3560] newton[_____] when hanger load is applied halfway between purlins by means of auxiliary support steel provided under this section. When support is not halfway between purlins, the allowable hanger load shall be the product of [400] [_____] times the inverse ratio of the longest distance to purlin-to-purlin spacing.

When the hanger load exceeds the above limits, reinforcing of purlin(s) or additional support beam(s) shall be provided. When an additional beam is used, the beam shall bear on the top chord of the roof trusses and bearing shall be over gusset plates of top chord. Beam shall be stabilized by connection to roof purlin along bottom flange.

Purlins used for supporting fire-protection sprinkler mains, electrical lighting fixtures, and electrical power duct or cable tray shall be considered fully loaded, and supplemental reinforcing or auxiliary support steel to support ductwork shall be provided for these purlins.

[Duct supports shall be vibration isolated from the structure.

Vibration isolators shall be provided in discharge ducting system for a distance not less than [50] feet [15] meter [_____] beyond the air handling unit. Deflection of duct and equipment mountings shall be coordinated.

Refer to Section 15072, "Vibration Isolation for Air Conditioning Equipment," for additional requirements.]

3.3 PLENUM CONSTRUCTION

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NOTE: This version is preferred as a supplement to the SMACNA HVAC DCS and provides for heavy sheet metal.

****

Intake and discharge plenum shall have companion angle joints with the following minimum thickness of materials:

LONGEST ANGLES SIDE INCHES	SHEET METAL USS GAGE ALL SIDES	COMPANION ANGLES INCHES	REINFORCEMENT INCHES, 24 INCHES ON CENTER MAXIMUM
To 48	20	1-1/2 by 1-1/2 by 1/8	1-1/2 by 1-1/2 by 1/8
49 to 84	18	2 by 2 by 1/8	2 by 2 by 3/16
85 to 120	16	2 by 2 by 1/8	2 by 2 by 1/8
121 and larger	14	2 by 2 by 3/16	2 by 2 by 3/16

LONGEST ANGLES SIDE MILLIMETER	SHEET METAL USS GAGE ALL SIDES	COMPANION ANGLES MILLIMETER	REINFORCEMENT INCHES, 610 MM ON CENTER MAXIMUM
To 1220	1.0	40 by 40 by 3	40 by 40 by 3
1245 to 2135	1.3	50 by 50 by 3	50 by 50 by 4.7

LONGEST ANGLES SIDE MILLIMETER	SHEET METAL USS GAGE ALL SIDES	COMPANION ANGLES MILLIMETER	REINFORCEMENT INCHES, 610 MM ON CENTER MAXIMUM
2160 to 3048	1.6	50 by 50 by 3	50 by 50 by 3
3075 and larger	2.0	50 by 50 by 4.7	50 by 50 by 4.7

At the floor line and other points where plenums join masonry construction, panels shall be bolted [12] inches [300] millimeter [_____] on center to [2- by 2- by 3/1650 by 50 by 4.7] [_____] inch millimeter thick hot-dip galvanized steel angle that has been secured to the masonry with masonry anchors and bolts [24] inches [600] millimeter [_____] on center and calked tight to the masonry.

Panels shall be anchored to curbing by not less than [2- by 2- by 3/1650 by 50 by 4.7] [_____] inch millimeter thick hot-dip galvanized steel angle iron. Concrete curbing shall include angle iron nosing with welded studs for the anchoring of panels. Nosing shall be level at curb height within plus or minus [1/16] inch [1] millimeter [_____].

Plenum access doors shall be constructed in accordance with SMACNA HVAC DCS except that access doors smaller than man-access doors shall have door openings framed with angle iron that is one commercial size smaller than specified panel reinforcement.

Man-access door size shall be per SMACNA HVAC DCS and paragraph entitled, "Access Openings," of this section. Insulated and uninsulated construction shall be per SMACNA HVAC DCS. Door openings shall be framed with channel iron. Doors shall be framed with angle iron. Channel iron and angle iron shall be approximately the same size as specified panel reinforcement. Exterior door skin shall be [16] gage [1.6] millimeter [_____]. Latches shall be fabricated steel, hinges shall be at least [4] inches [100] millimeter [_____] long, and bolting shall be at least [3/8]-inch [10] millimeter [_____] diameter.

Angle iron and channel iron shall have welded and ground miter corners.

3.4 MANUAL VOLUME DAMPERS

Balancing dampers of the splitter, butterfly, or multilouver type, shall be provided to balance each respective main and branch duct.

Dampers regulated through ceilings shall have regulator concealed in box mounted in the ceiling, with a cover finish aesthetically compatible with ceiling surface. Where ceiling is of removable construction, regulators shall be above ceiling, and location shall be marked on ceiling in a manner acceptable to the Contracting Officer.

3.5 FLEXIBLE CONNECTORS FOR SHEET METAL

Air handling equipment, ducts crossing building expansion joints, and fan

inlets and outlets shall be connected to upstream and downstream components by treated woven-cloth connectors.

Connectors shall be installed only after system fans are operative, and vibration isolation mountings have been adjusted. When system fans are operating, connectors shall be free of wrinkle caused by misalignment or fan reaction. Width of surface shall be curvilinear.

3.6 INSULATION PROTECTION ANGLES

Galvanized [20]-gage [1.0] millimeter [_____] sheet steel, formed into an angle with a [2]-inch [50] millimeter [_____] exposed long leg with a [3/8]-inch [10] millimeter [_____] stiffening break at outer edge, and with a variable concealed leg, depending upon insulation thickness shall be provided.

Angles shall be installed over insulation edges terminating by butting against a wall, floor foundation, frame, and similar construction. Angles shall be fastened in place with blind rivets through the protection angle, insulation, and sheet metal duct or plenum. Angles shall be installed after final insulation covering has been applied.

3.7 DUCT PROBE ACCESS

Holes shall be provided with neat patches, threaded plugs, or threaded or twist-on caps where indicated, and where necessary, for air-balancing pitot tube access. Extended-neck fittings shall be provided where probe access area is insulated.

3.8 OPENINGS IN ROOFS AND WALLS

[Building openings are fixed and equipment shall be provided to suit. Contractor may propose to alter these openings upon prior approval, and at his expense.]

[Openings indicated in outside walls and roof are approximate.]

3.9 DUCTWORK CLEANING PROVISIONS

Open ducting shall be protected from construction dust and debris in a manner approved by the Contracting Officer. Dirty assembled ducting shall be cleaned by subjecting main and branch interior surfaces to air streams moving at velocities [two] [_____] times the specified working velocities, at static pressures within maximum ratings. Ducting shall be cleaned by a method approved by the Contracting Officer. Compressed air used for cleaning ducting shall be water- and oil-free. Prior to acceptance of the work, dust and debris shall be removed from exterior surfaces.

3.10 FIRE DAMPER TESTS

[Operation tests shall be performed on each fire damper in the presence of the Contracting Officer by enervating fusible link with localized heat. New links shall be provided and installed after successful testing.]

3.11 DUCTWORK LEAKAGE TESTS

Contractor shall conduct leakage test on new duct in accordance with Section 15950, "Testing, Adjusting and Balancing." Test shall be performed prior to installing ductwork insulation.

3.12 OPERATION AND MAINTENANCE

Operation and Maintenance Manuals shall be consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures and safety precautions.

-- End of Section --